OCR
Oxford Cambridge and RSA

Wednesday 18 May 2022 – Morning

AS Level Physics A

H156/01 Breadth in physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

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H 1 5 6 0 1

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a maximum of 25 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which of the following could be the wavelength of ultraviolet radiation?

A 3×10^{-5} m

B 1×10^{-10} m

C 4×10^{2} m

D 2×10^{-7} m

Your answer ☐ **[1]**

2 Which term is **not** used in either of Kirchhoff's two laws?

A charge

B current

C electromotive force

D potential difference

Your answer ☐ **[1]**

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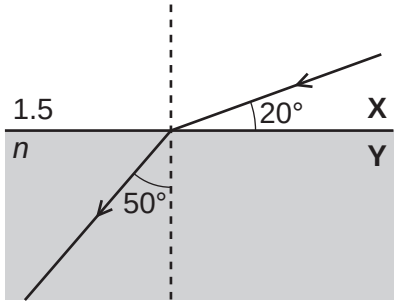
3 The diagram below shows the refraction of light at the boundary between two transparent materials **X** and **Y**.



The refractive index of material **X** is 1.5 and the refractive index of material **Y** is n.

Which of the following expressions is correct?

A $n \times \sin 70° = 1.5 \times \sin 50°$

B $n \times \sin 20° = 1.5 \times \sin 40°$

C $1.5 \times \sin 70° = n \times \sin 50°$

D $1.5 \times \sin 20° = n \times \sin 40°$

Your answer ☐ **[1]**

4 A student is carrying out the Young double-slit experiment using visible light.
The distance between the slits and the screen is kept constant.
The wavelength of light is λ and the separation of the slits is a.

The following results are collected by the student.

	λ / nm	**a / mm**
A	450	0.20
B	510	0.15
C	550	0.25
D	610	0.30

Which combination of λ and a will give the **largest** separation between the adjacent bright fringes?

Your answer ☐ **[1]**

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5 A car of mass 1000 kg is travelling on a straight and horizontal road.
The driver applies the brakes.
The speed of the car decreases from 20 m s^{-1} to 15 m s^{-1} in 2.4 s.
What is the average power dissipated by the brakes?

A 1.0×10^3 W

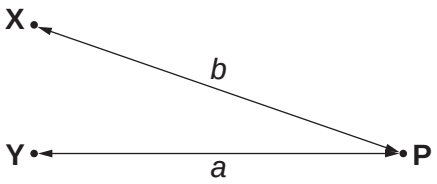
B 5.2×10^3 W

C 3.6×10^4 W

D 8.3×10^4 W

Your answer ☐ **[1]**

6 Two coherent waves are emitted from the sources **X** and **Y**.



The diagram is not to scale.
The waves at **X** and **Y** are in phase.
The waves have wavelength 4.0 cm.
The phase difference of the two waves meeting at point **P** is 270°.

Which row gives possible distances for *a* and *b*?

	a **/ cm**	***b*** **/ cm**
A	20.0	26.0
B	20.0	22.0
C	15.0	18.0
D	10.0	14.0

Your answer ☐ **[1]**

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7 A resistor of resistance 12 Ω is connected in **parallel** with another resistor of resistance *R*. The total resistance of the circuit is 4.0 Ω.

What is the value of *R*?

A 0.17 Ω

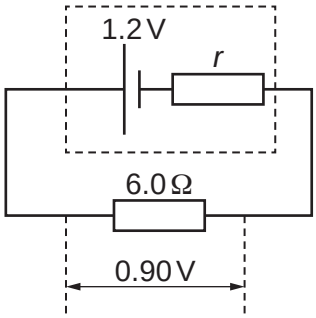
B 6.0 Ω

C 8.0 Ω

D 16 Ω

Your answer ☐ **[1]**

8 A cell of electromotive force (e.m.f.) 1.2 V is connected to a wire of resistance 6.0 Ω.



The potential difference across the wire is 0.90 V.

What is the internal resistance *r* of the cell?

A 0.15 Ω

B 0.30 Ω

C 2.0 Ω

D 8.0 Ω

Your answer ☐ **[1]**

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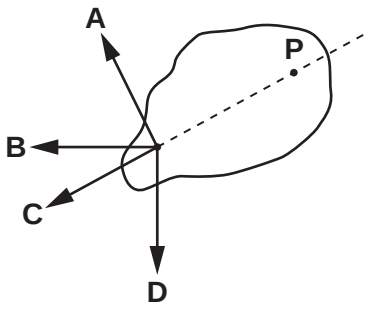
9 A thin metal plate is free to rotate in the vertical plane about the point **P**.
Four forces **A**, **B**, **C** and **D** act at the same point on the plate, as shown below.



The diagram above is drawn to scale.
All the forces are in the vertical plane.
The forces have the same magnitude but act in different directions.

Which force will produce the **greatest** moment about point **P**?

Your answer ☐ **[1]**

10 A total of 3.8×10^{7} electrons flow through a wire in a time of $1.2\,\mu s$.

What is the current in the wire?

A 6.1×10^{-12} A

B 7.3×10^{-12} A

C 5.1×10^{-6} A

D 3.2×10^{13} A

Your answer ☐ **[1]**

11 An electric motor is used to lift a weight of 4.0 N through a vertical height of 0.90 m in 1.8 s.
The efficiency of the motor is 20%.

What is the electrical power supplied to the motor?

A 0.40 W

B 2.0 W

C 3.6 W

D 10 W

Your answer ☐ **[1]**

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12 Plane polarised light is incident perpendicular to a vertical polarising filter.
The polarising filter is rotated about the horizontal axis.

Which property of the transmitted light changes as the filter is rotated?

A frequency

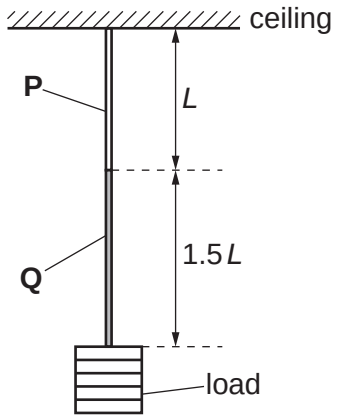
B intensity

C speed

D wavelength

Your answer ☐ **[1]**

13 A load is suspended from two wires **P** and **Q** as shown below.



Both wires have the same diameter.

The table below shows some data for these two wires.

	Original length of wire	**Young modulus of wire's material**	**Extension of wire / mm**
P	L	E	4.0
Q	$1.5L$	$3.0E$	

What is the extension of the wire **Q**?

A 2.0 mm

B 4.0 mm

C 6.0 mm

D 8.0 mm

Your answer ☐ **[1]**

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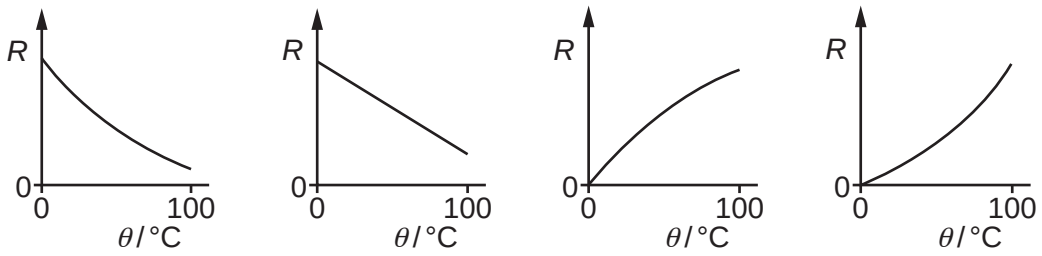
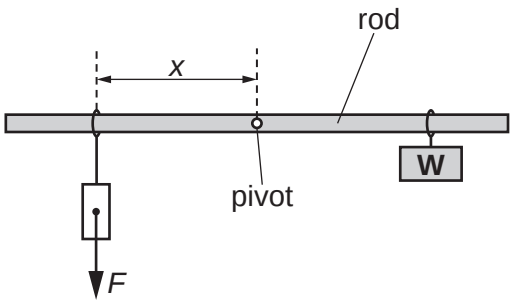
14 Which graph best represents the way in which the resistance R of a negative temperature coefficient (NTC) thermistor depends on its temperature θ in °C?



Your answer ☐ **[1]**

15 A student balances a uniform metal rod horizontally.



The rod is pivoted at its middle. The position of weight **W** is kept constant.
The distance of the weight F from the pivot is x. The student changes F and then adjusts x so that the rod remains balanced.

Which statement is correct?

A A graph of F against x will be a straight line through the origin.

B The upward force at the pivot is equal to F.

C The weight of **W** is equal to Fx.

D x is inversely proportional to F.

Your answer ☐ **[1]**

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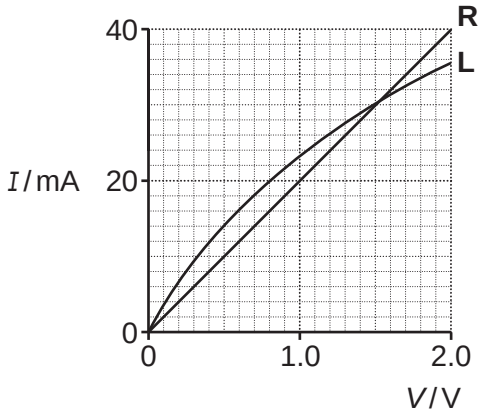
16 The *I*-*V* characteristics of two components **R** and **L** are shown below.



Which statement is correct?

A **R** and **L** are both filament lamps.

B **R** and **L** have the same resistance at 1.5 V.

C The resistance of **L** is independent of potential difference *V*.

D The resistance of **R** increases as the potential difference *V* increases.

Your answer ☐ **[1]**

17 The photoelectric effect can be demonstrated using a gold-leaf electroscope.
The zinc plate of the electroscope is negatively charged.
Ultraviolet radiation incident on the zinc collapses the gold leaf.

What is removed from the zinc plate by the incident radiation?

A electrons

B ions

C photons

D protons

Your answer ☐ **[1]**

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18 What is the total energy E gained by N electrons travelling through a potential difference V?

A $E = N \times V$

B $E = V \times 10^{-19}$

C $E = V \times 1.60 \times 10^{-19}$

D $E = N \times V \times 1.60 \times 10^{-19}$

Your answer ☐ **[1]**

19 A student is experimenting with sound waves of wavelength 3.0 cm and electromagnetic waves also of wavelength 3.0 cm.

Which statement is correct about **both** of these waves?

A They can be polarised.

B They can form stationary waves.

C They have the same frequency.

D They have the same speed.

Your answer ☐ **[1]**

20 A laser emits a uniform beam of light.

What two quantities alone are required to calculate the intensity of the beam of light?

A amplitude, frequency

B cross-sectional area, power

C energy, time

D frequency, wavelength

Your answer ☐ **[1]**

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Question 21 starts on page 12

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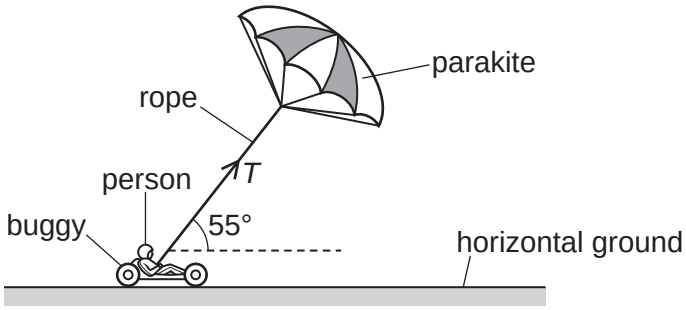
SECTION B

Answer **all** the questions.

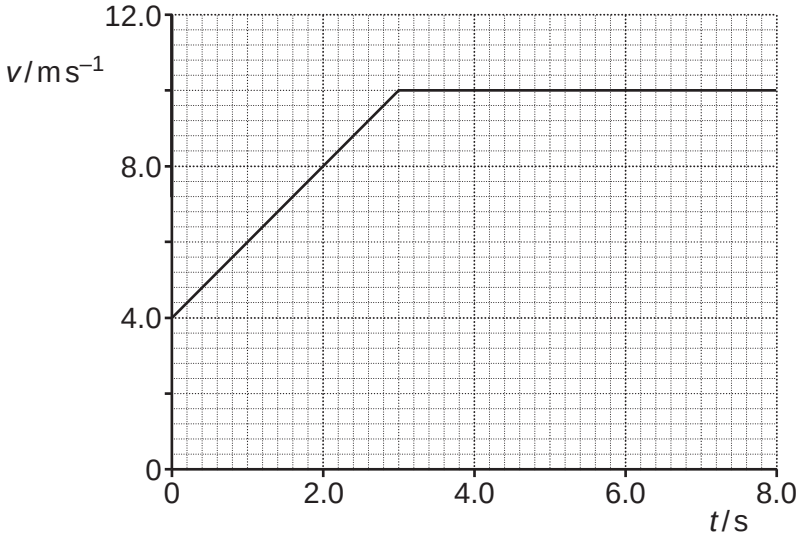
21 A person in a buggy is attached to a large parakite by a rope, as shown below.



Strong wind acting on the parakite moves the buggy along horizontal ground.

The rope makes an angle of 55° to the horizontal. The total mass of the buggy and person is 150 kg.

The velocity v against time t graph for the buggy is shown below.



(a) Calculate the horizontal distance travelled by the buggy from $t = 0$ to $t = 8.0$ s.

horizontal distance = ... m **[3]**

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(b) At $t = 1.0\,s$ the buggy is accelerating.

(i) Use the graph to show that the acceleration of the person at $t = 1.0\,s$ is $2.0\,m\,s^{-2}$.

[1]

(ii) At $t = 1.0\,s$ the tension T in the rope is $680\,N$ and the total **horizontal** resistance acting on the buggy and person is R.

Calculate R by resolving the tension in the rope horizontally.

$R =$ ..... N **[3]**

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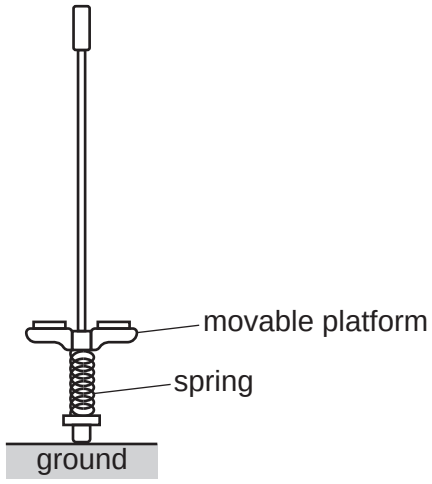
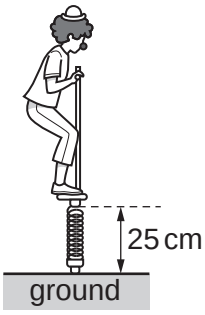
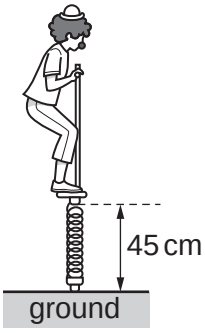
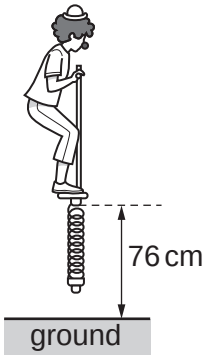
22 A pogo stick is a spring-based toy used by a circus clown for jumping vertically up and down. A **compression** spring is fixed to the bottom of the pogo stick. The upper end of the spring is attached to a movable platform.



The force constant of the spring is $1.7 \times 10^4\,\text{N m}^{-1}$.
The mass of the clown is 68 kg.
The mass of the pogo stick is negligible compared with the mass of the clown.

The table below shows the state of the spring and the clown in three different positions.

	Position A	**Position B**	**Position C**
			
State of spring	fully compressed	original length	original length
State of clown	stationary	Moving vertically upwards at maximum speed	stationary
Height of platform above the ground / cm	25	45	76

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(a) Describe how the force constant of the compression spring in the pogo stick can be verified in the laboratory.

.....

.....

.....

..... **[2]**

(b) Describe the energy changes taking place between positions **B** and **C**.

.....

..... **[1]**

(c) Calculate the maximum energy E stored in the compressed spring.

E = ... J **[2]**

(d) A student uses the following expression to determine the maximum speed v of the clown in position **B**:

maximum energy E stored in the compressed spring = $\frac{1}{2} \times 68 \times v^2$.

Explain why this expression is incorrect. You are not expected to do any calculations.

.....

..... **[1]**

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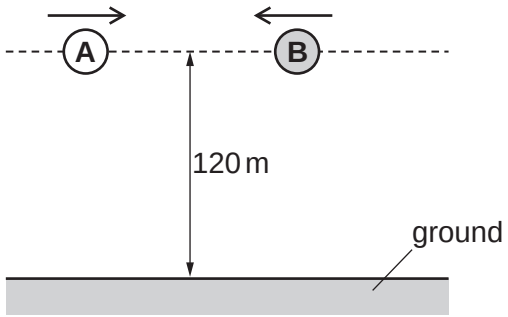
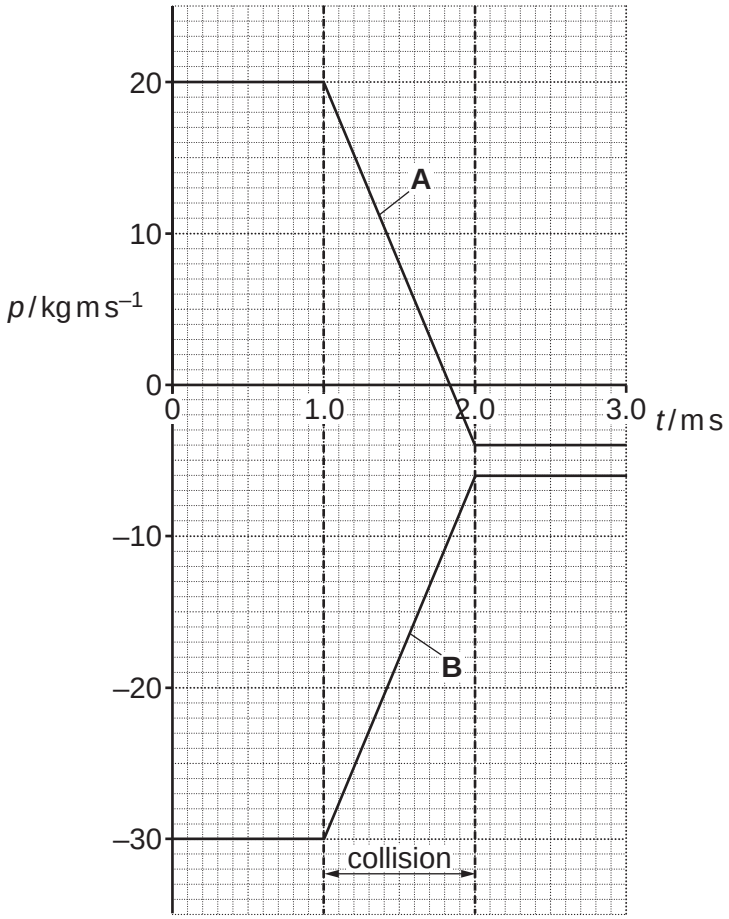
23 Two objects **A** and **B** are travelling horizontally and in opposite directions. The objects collide in mid-air at a height of 120 m above the horizontal ground, as shown below.



The mass of **A** is 2.0 kg and the mass of **B** is 3.0 kg.

After the collision the objects are joined together.

The momentum p against time t graphs for each object before, during and after the collision are shown below.



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(a) Explain how the graphs demonstrate Newton's third law during the collision.

.....

.....

..... **[2]**

(b) Use the graphs to show that momentum is conserved in the collision.

[2]

(c) Calculate the magnitude of the horizontal velocity v of the combined objects immediately after the collision.

v = ... $m\,s^{-1}$ **[2]**

(d) Air resistance has negligible effect on the motion of the objects.

Calculate the time taken for the combined objects to reach the ground after the collision.

time taken = ... s **[3]**

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24 (a) **Stationary** waves are formed on the surface of seawater in a harbour as incoming waves are reflected off the harbour wall.

An observer is looking at these stationary waves.

State how the observer can tell that these are stationary waves.

.....

..... **[1]**

(b) A wire is fixed between two supports, as shown in **Fig. 24**.

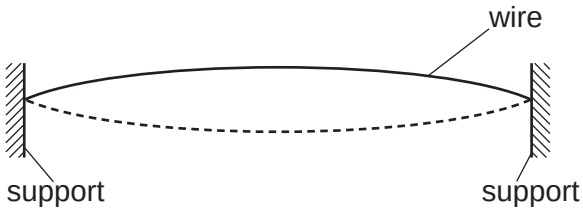

Fig. 24

The wire is plucked in the middle. A stationary wave of fundamental frequency f is formed on the stretched wire.

The tension T in the stretched wire is given by the expression $T = 4f^2mL$, where f is the frequency of the oscillating wire, m is the mass of the wire and L is the length of the wire.

A student is performing an experiment to determine the tension T in the wire. The measurements are shown in the table below.

Quantity	Measurement	Percentage uncertainty
f	58 Hz	2.5
m	9.7×10^{-4} kg	1.0
L	0.62 m	0.5

(i) Suggest how the student may have determined the fundamental frequency of the oscillating wire in the laboratory.

.....

.....

.....

..... **[2]**

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(ii) Use the data in the table to determine

1 the wavelength of the progressive waves on the stretched wire

wavelength = ... m **[1]**

2 the speed of the progressive waves on the stretched wire

speed = ... $m\,s^{-1}$ **[2]**

3 the **absolute** uncertainty in the tension T. Write your answer to 2 significant figures.

absolute uncertainty in T = ... N **[2]**

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25 **(a)** Potential difference (p.d.) and electromotive force (e.m.f.) can both be defined in terms of transfer of energy per unit charge.

State one other **similarity** between p.d. and e.m.f.

.....

..... **[1]**

(b) **Fig. 25.1** shows an electrical circuit.

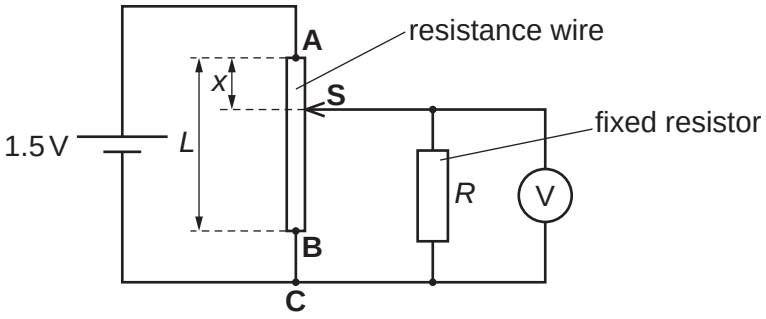

Fig. 25.1

The cell has e.m.f. 1.5 V and negligible internal resistance.

AB is a resistance wire of length *L*. The resistance of this wire is **equal** to the resistance *R* of the fixed resistor.
S is a sliding contact that can be moved on the resistance wire. The distance between **A** and **S** is *x*.
The p.d. across the fixed resistor is *V*.

(i) The distance *x* is changed by moving the slider from **A** to **B**.

On **Fig. 25.2**, show the variation of *V* with distance *x*.

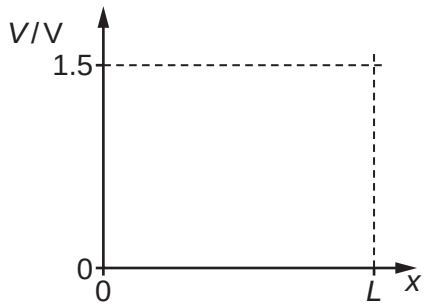

Fig. 25.2

[2]

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(ii) The connecting wire **BC** is now removed. The rest of the circuit remains unchanged.

Explain the variation of V with distance x as **S** is moved from **A** to **B**.

.....

.....

.....

..... **[2]**

(c) A power supply of electromotive force (e.m.f.) 14.4 V and negligible internal resistance is connected by two identical metal wires to two filament lamps, as shown in **Fig. 25.3**.

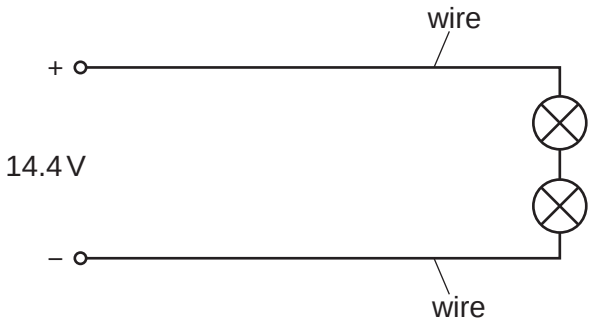

Fig. 25.3

The current in the circuit is 3.0 A.
The potential difference across **each** lamp is 6.0 V.
The **total** length of the metal wire is 25.0 m. The cross-sectional area of the wire is 0.54 mm^2.

(i) Calculate the resistivity ρ of the metal from which the wire is made.

ρ = ... Ω m **[4]**

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(ii) The number of electrons per unit volume n in the metal wire is $8.5 \times 10^{28}\,\text{m}^{-3}$.

Calculate the mean drift velocity v of the electrons in the metal.

v = ... m s^{-1} **[2]**

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26 **(a)** The table below shows the work function ϕ of four metals.

Metal	**A**	**B**	**C**	**D**
ϕ/eV	3.2	4.1	3.3	6.4

Electromagnetic radiation of wavelength 380 nm is incident on all the metals.
Photoelectrons are **just** emitted from metal **A**.

(i) Explain, in terms of the energy of photons, why metal **C** will **not** emit photoelectrons.

.....

..... **[1]**

(ii) Calculate the maximum wavelength of the electromagnetic radiation in nm that will **just** eject photoelectrons from metal **D**.

maximum wavelength = ... nm **[1]**

(iii) The metal **B** is now exposed to electromagnetic radiation of a different wavelength.
The energy of each incident photon is 5.3 eV.

Calculate the minimum de Broglie wavelength λ of the emitted photoelectrons.

λ = ... m **[3]**

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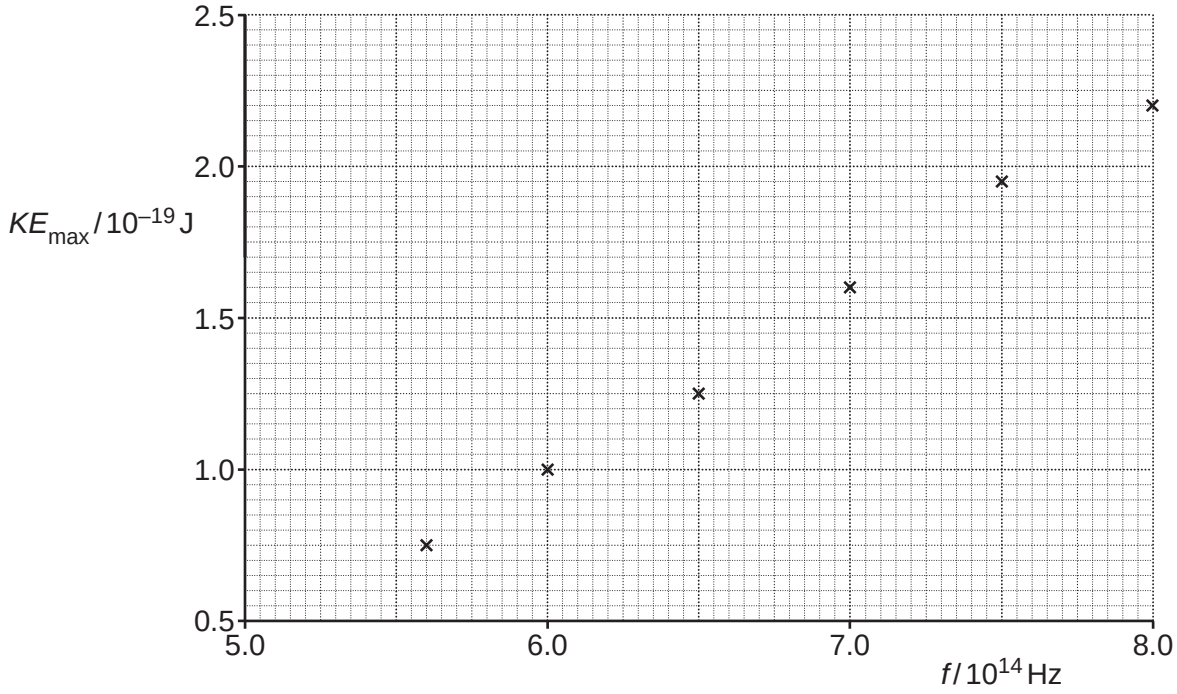
(b) A researcher is carrying out an experiment to determine the work function ϕ of a new material. The material is illuminated by electromagnetic radiation of frequency f and the maximum kinetic energy KE_{max} of the photoelectrons is determined.

The researcher plots the data points shown below.



(i) Draw a straight line of best fit through the data points. **[1]**

(ii) Use the gradient of this line, and Einstein's photoelectric equation, to determine the work function ϕ of the material.

ϕ = ... J **[3]**

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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